
Constellation-X
Facility Science Team Meeting
September 18/19, 2002
Goddard Space Flight Center
http://constellation.gsfc.nasa.gov

Project Management

Scott Lambros
Constellation-X Project Manager
Goddard Space Flight Center

Project Status and Update

▪ *Project Management*	*Scott Lambros (GSFC)*
▪ *Project Status Summary*	*Jean Grady (GSFC)*
▪ *Top-Level Reqmnts & Ops Concept*	*Jay Bookbinder (SAO)*
▪ *Mission Performance Prediction Updates*	*Bill Podgorski (SAO)*
▪ *Reference Mission Architecture and Design Update*	*Govind Gadwal (GSFC)*

Constellation-X Project Management Organization

- ***Scott Lambros/Constellation-X Project Manager***
  - ***301-286-0118***
  - ***scott.lambros@gsfc.nasa.gov***

- ***Jean Grady/Deputy Project Manager***
  - ***Will continue to concentrate on technology development***

- ***Augmenting Project Staff***
  - ***Instrument Manager***
  - ***Instrument Systems Engineer***

Technology Readiness & Implementation Plan Review

- *NASA HQ review of Constellation-X and LISA*
  - *Charter by first week of October 2002*
- *Report due beginning of February 2003*
- *Site Visit March 2003*
- *Constellation-X preparations*
  - *Level 1 Requirements and Flowdown*
  - *Technology development plans to TRL 6*
  - *Implementation Plan*
  - *Significant prototyping events which can be completed by February or March ´03*
  - *Cost*
    - *Technology development*
    - *Mission lifecycle: cost models with some grass-roots comparisons*
  - *Schedule*

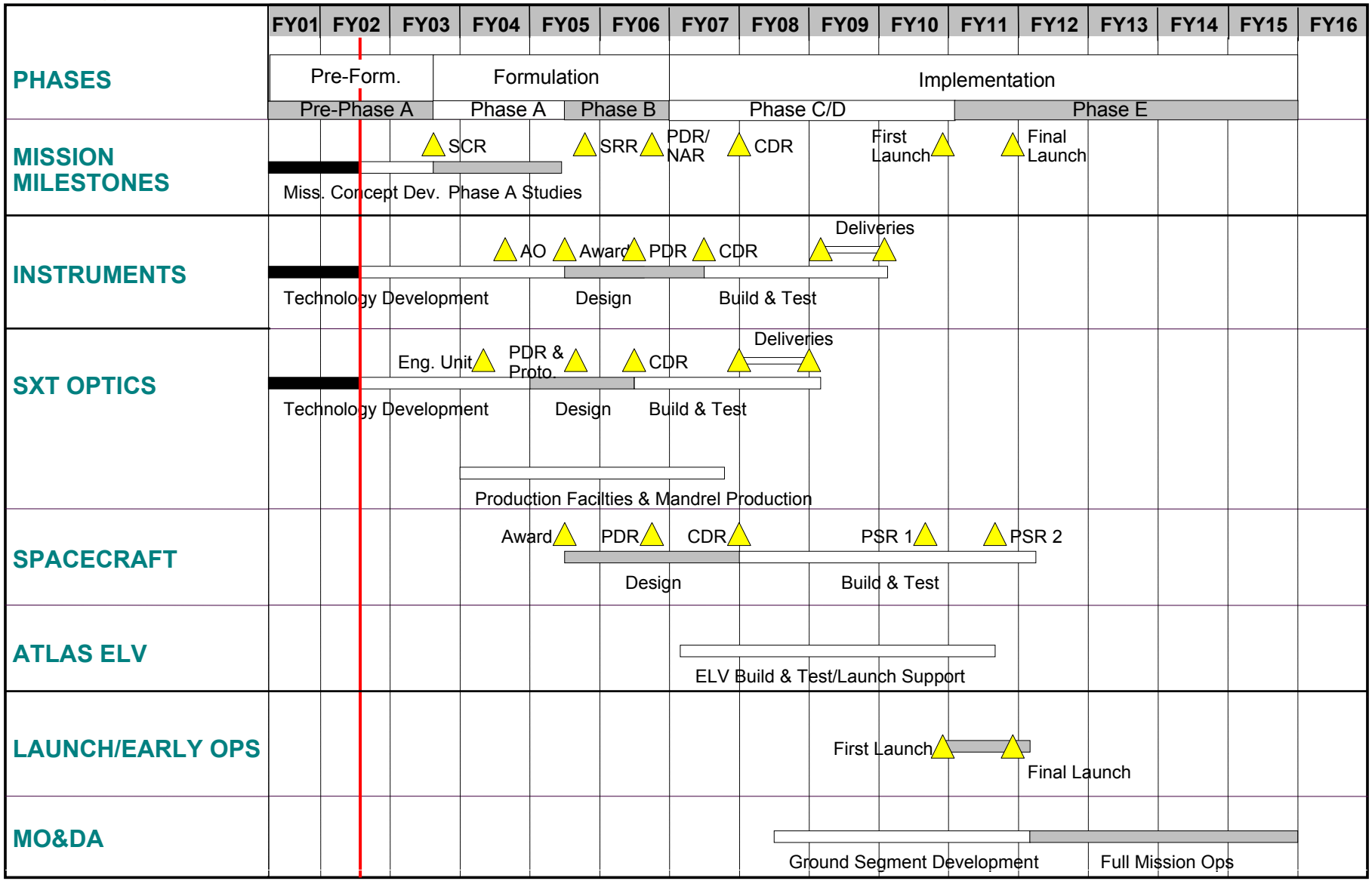
Industry Mission Studies

- ***Industry Pre-phase A mission and spacecraft studies planned to be issued through the Rapid Spacecraft Development Office (RSDO) in FY03***
- ***Up to four study contracts will be awarded with nominal duration of 4 months***
- ***Objectives of studies***
  - ***Develop mission and spacecraft concepts***
  - ***Develop independent cost estimates***
  - ***Assess RSDO as vehicle for Constellation-X***
  - ***Position mission for strong entry into Phase A***
  - ***Build partnerships with potential industry partners***
- ***Nominal Schedule:***

– ***Draft Request for Offer (RFO)***	***End 2002***
– ***Release RFO***	***1st Quarter 2003***
– ***Award Study***	***May 2003***
– ***Final Report/Presentation***	***September 2003***

- ***Potential RSDO vendors attending FST meeting***

Constellation-X Top-Level Schedule



Project Status Summary

Jean Grady
Constellation-X Deputy Project Manager
Goddard Space Flight Center

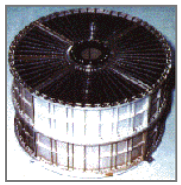
Project Highlights Since Nov 2002 FST

- *Held Technology Meeting on May 1, 2002 in Greenbelt, MD*
- *Supported SEU Roadmap Subcommittee in May 2002*
- *Held "Executive" Technology Planning Meeting on August 15, 2002*
- *Developing and Updating Project documents which will be applicable to Independent Review and Industry Mission Studies (RSDO)*
  - *Reference Mission Architecture and Design Document*
  - *Draft Reference Operations Concept Document*
  - *Design Reference Mission Science Observation Set*
  - *Level 1 and 2 Requirements*
  - *Reference Instrument Interface Document*
  - *Technology Roadmap Document*

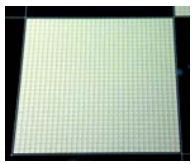
Technology Development Highlights

- ***SXT Optics***
  - ***Optics "Pathfinder" Assembly #1 has been designed and built; alignment tests are underway***
  - ***Second pathfinder to follow with emphasis on demonstrating X-ray performance***
- ***X-ray Calorimeter***
  - ***4-pixel array demonstrations expected in early FY 2003 for both TES and NTD/Ge***
- ***Grating***
  - ***Parallel development of in-plane and off-plane approaches***
- ***CCD***
  - ***Changing baseline for technology development to Event-Driven CCDs***
  - ***Generation 1 devices fabricated***
- ***Hard X-ray Telescope***
  - ***Continuing to develop shell and segmented small optics prototypes***

Constellation-X Summary Technology Roadmap

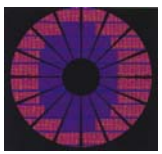


X-ray Mirrors



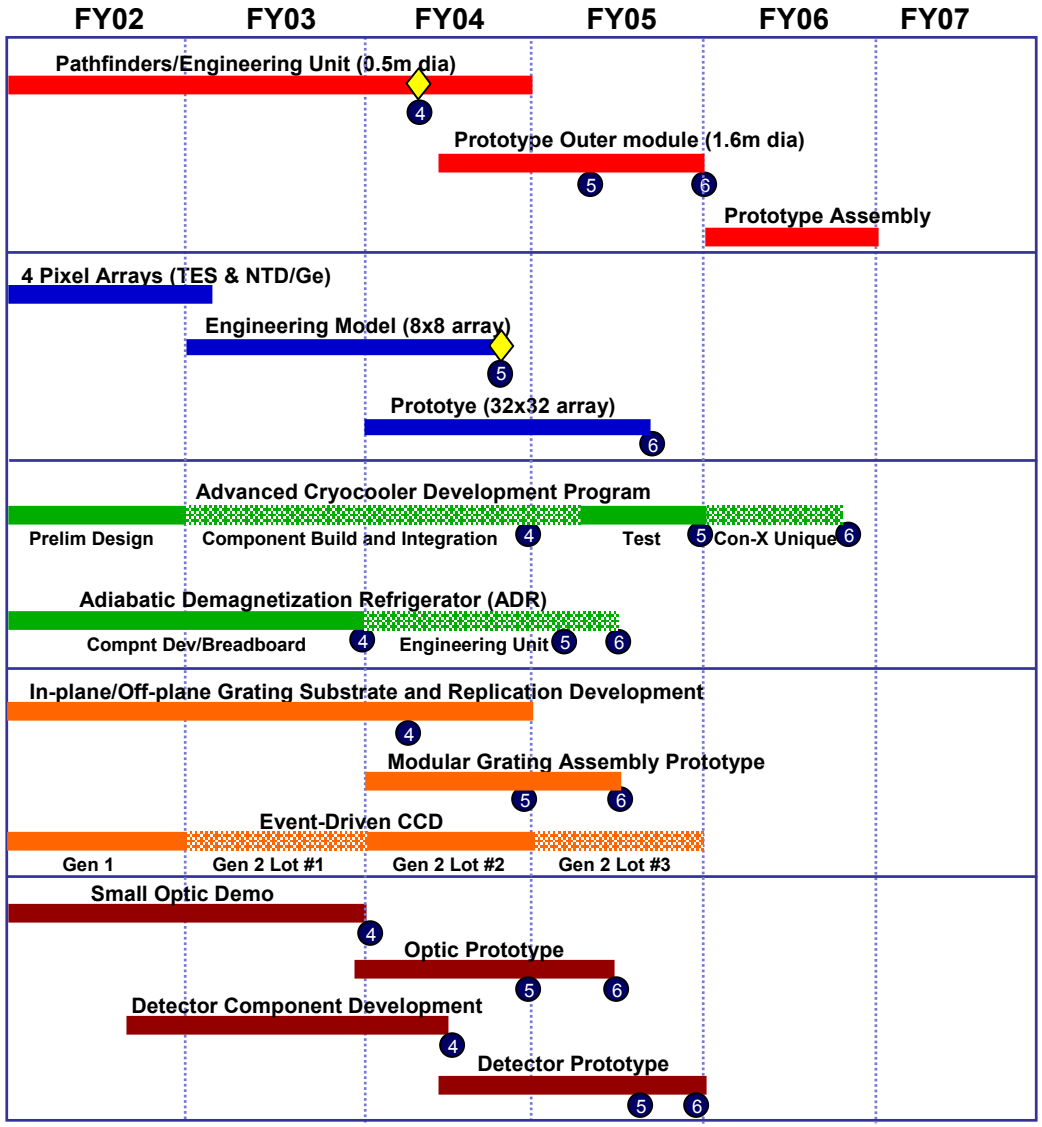
X-ray Calorimeters

Cryocoolers and ADR



Grating/CCD

Hard X-ray Telescope



Top-Level Requirements and Operations Concept

Jay Bookbinder
Smithsonian Astrophysical Observatory

Top Level Requirements Status

- *The 28 requirements in the top level are unchanged since 8/01 release of the document*
- *A Level 1 Requirements Document is in preparation to support the TRIP review process: final draft in November 02. This draft will incorporate significant inputs from the last FST meeting.*
- *5 key science requirements are under review. FST inputs/advice are encouraged:*
  - *Mission Bandpass*
  - *Mission Minimum Resolution*
  - *Resolution at 6 keV*
  - *Angular Resolution below 10 keV*
  - *SXT Effective Areas*

Mission Bandpass

Requirement: 0.25 to 40 keV (current goals are <0.2 and >60 keV)

- ***Suggestions:***
  - ***Add goal for low energy of 0.1 keV? (potentially feasible with move to EDCCD: reasonable A_{eff} to 0.1keV)***
  - ***Increase high energy requirement to 60 keV? (appears feasible from technology perspective). What about Ti lines?***
  - ***Set a new goal above that?***
- ***Issues:***
  - ***What should the effective area requirements be at these energies?***
- ***Impacts:***
  - ***CCD array length & associated***
- ***Plan:***
  - ***Implement FST and mission team recommendations.***
  - ***See presentations by: W. Cash, F. Harrison, R. Smith***

Minimum Resolving Power

Mission Minimum Resolving Power:

- *0.25-10 keV = 300 (goal 600)*
- *6-8.5 keV = 3000 (goal TBD)*
- *10-40 keV = 10 (goal TBD)*
  - *Suggestions:*
    - *Set goal for a minimum of ~1,000 based on Chandra and XMM results and potential capabilities of the off-plane gratings?*
  - *Issues:*
    - *Location of crossover to gratings; What should the actual minimum resolution be? And what is achievable?*
  - *Impacts:*
    - *Many – i.e., grating alignment tolerances, calibration requirements, etc.*
  - *Plan:*
    - *Grating approach study underway with downselect at end of FY03. Need additional science studies on resolution requirements for collisionless and non-maxwellian plasmas.*
  - *See presentations by:*
    - *A. Rasmussen, W. Cash, R. Smith, N. Brickhouse, F. Walter, H. Marshall*

Resolving Power at 6 keV

Mission Resolving Power:

- *0.25-10 keV = 300 (goal 600)*
- *6-8.5 keV = 3000 (goal TBD)*
- *10-40 keV = 10 (goal TBD)*
  - *Suggestions:*
    - *Change to goal of 2 eV, and requirement of 4 eV at 6 keV? (note, this keeps the 2eV requirement near 1 keV).*
  - *Issues:*
    - *What are the science impacts?*
  - *Plan:*
    - *Implement FST and mission team recommendations.*
  - *See presentations by:*
    - *Duane Liedahl (?)*

Angular Resolution

Angular resolution:

- ***15 arcsec (current goal 5 arcsec) below 10 keV***
  - ***Issues: Chandra deep fields verify this is well matched to source confusion – but 5 arc sec goal would be helpful for crowded fields (especially galaxies). This is not a new issue…***
  - ***Impacts: Calorimeter pixel and array sizes, thermal loading***
  - ***Plan: Monitor technology development status***
  - ***See presentation by Petre***

Effective Areas

Minimum effective areas:

- ***@ 0.25 keV = 1,000 cm2***
- ***@ 1.25 keV = 15,000 cm2***
- ***@ 6.4 keV = 6,000 cm2***
  - ***Status, Issues, Impacts and Plan:***
    - ***See presentation by Bill Podgorski***

Science-Based Trades Required

- *Calorimeter: 2 eV vs. 4 eV resolution @ 6 keV*
- *CCD/Grating: Extending low energy range below 0.25 keV*
- *Mission Minimum Resolution: Studies for collisional and collisionless plasmas, absorption spectra, and non-maxwellian plasmas*
- *HXT: Extend high energy range to >60 keV*

Operations Concept

Operations Concept Key Requirements:

- ***An overall viewing efficiency of 90% (i.e., must account for slew times, target acquisitions, nominal calibrations, engineering time, radiation events, etc.)***
- ***Timing accuracy 100 microsec (goal of 50)***
- ***Celestial location accuracy of 5 arcsec***
- ***2-week data latency***
- ***Calibration requirements***

Operations Concept Methodology

Significant progress has been made in identifying and documenting the first-cut Constellation-X operations concept

- ***Methodology***
  - ***Identify key mission, science, and spacecraft drivers from an operability standpoint (how?, who?, when?)***
  - ***Define key operational tasks and their interrelationships via thread and timeline analysis***
  - ***Map tasks to performing operations elements (people, ground data system, on-board computer, etc.)***
  - ***Document and iterate, refining the concept as Con-X matures — early enough to influence space segment and ground system design, including pre-launch activities***

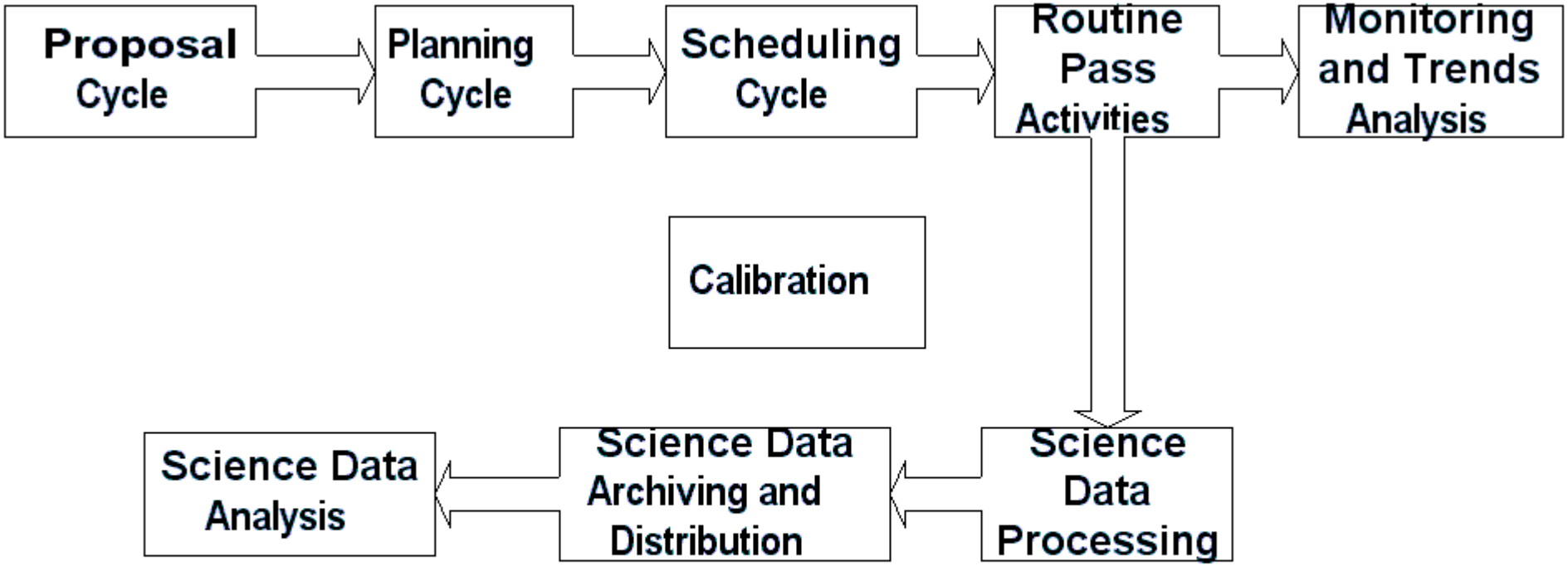
Operations Concept Status

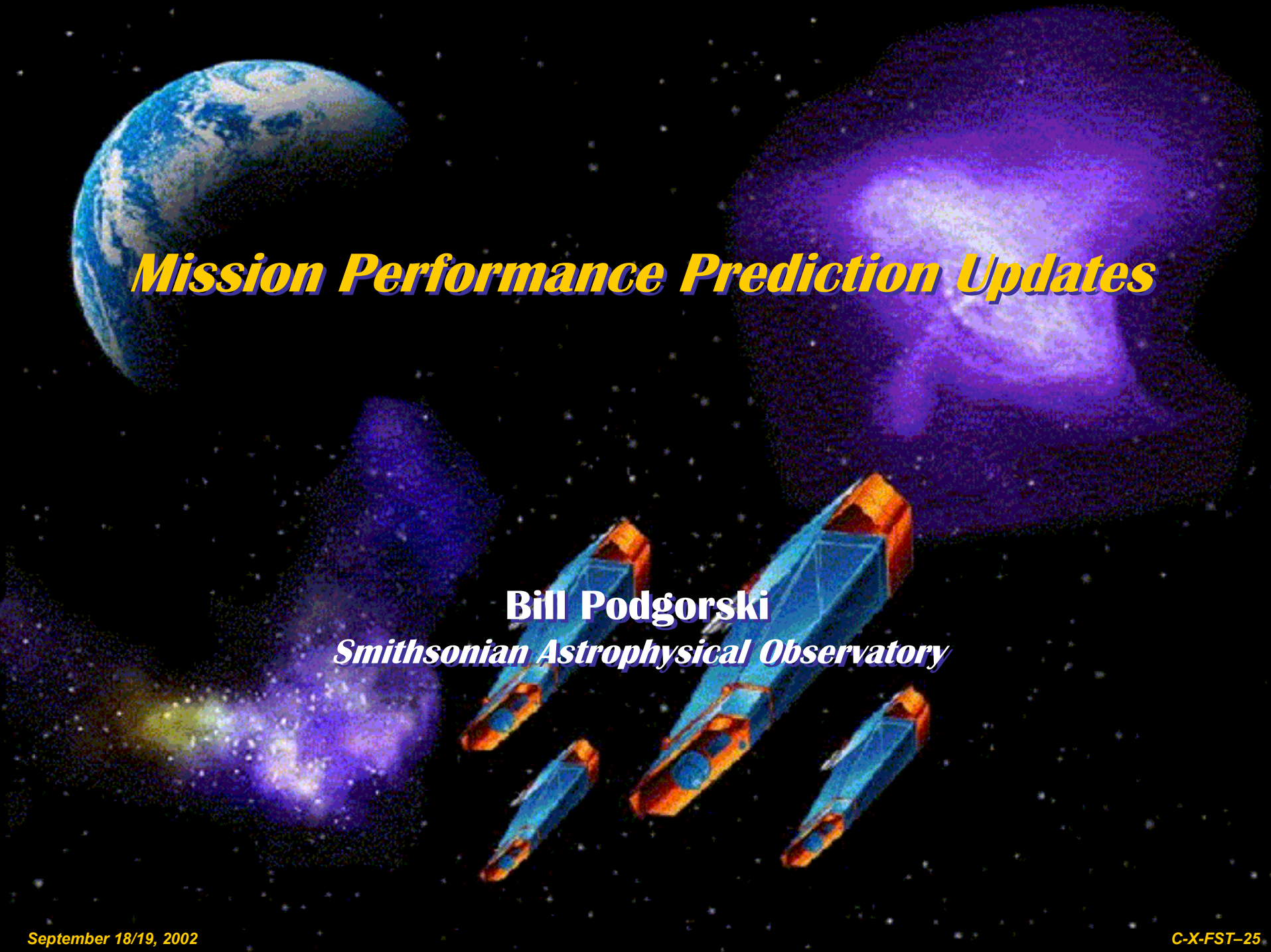
Status

- ***Inputs have been received from GSFC and SAO personnel and integrated into an initial draft***
- ***The primary operations threads through the various ops elements have been identified, including the science elements***
- ***TBDs are used liberally at his stage, with key assumptions and potential trades identified up front***
- ***Completeness checks are in place within the document***
- ***First draft released in time to support TRIP review (early December).***
- ***Will use the DRM to identify and refine requirements, identify potential problem areas.***

Backup Slides

Primary Operational Thread





Mission Performance Prediction Updates

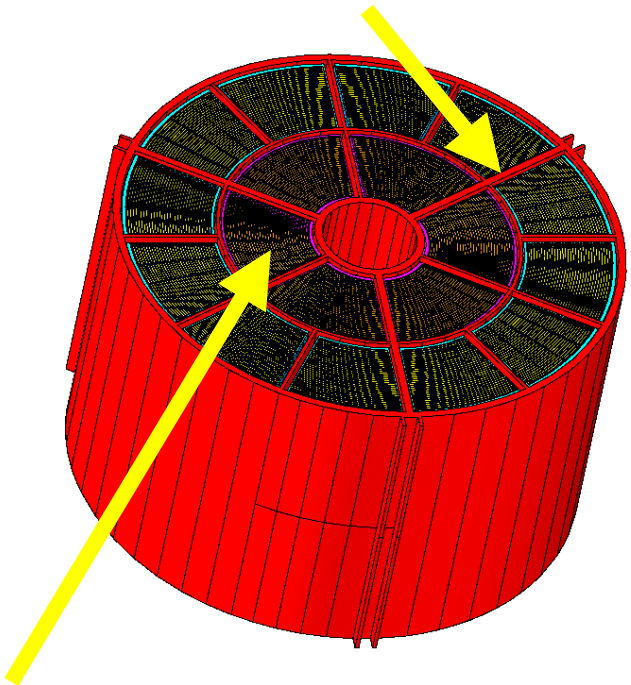
Bill Podgorski
Smithsonian Astrophysical Observatory

SXT Effective Area

- *SXT Design*
  - *Segmented optics made baseline*
  - *Modular GSFC design*
- *Grating/CCD Instrument*
  - *In-plane/off-plane options being considered*
  - *Revisions to in-plane grating efficiencies*
  - *Event Driven CCD made baseline*
- *Micro-calorimeter Instrument*
  - *No changes*

SXT Design Impacts On Effective Area

Outer Modules (12 P and 12 H)



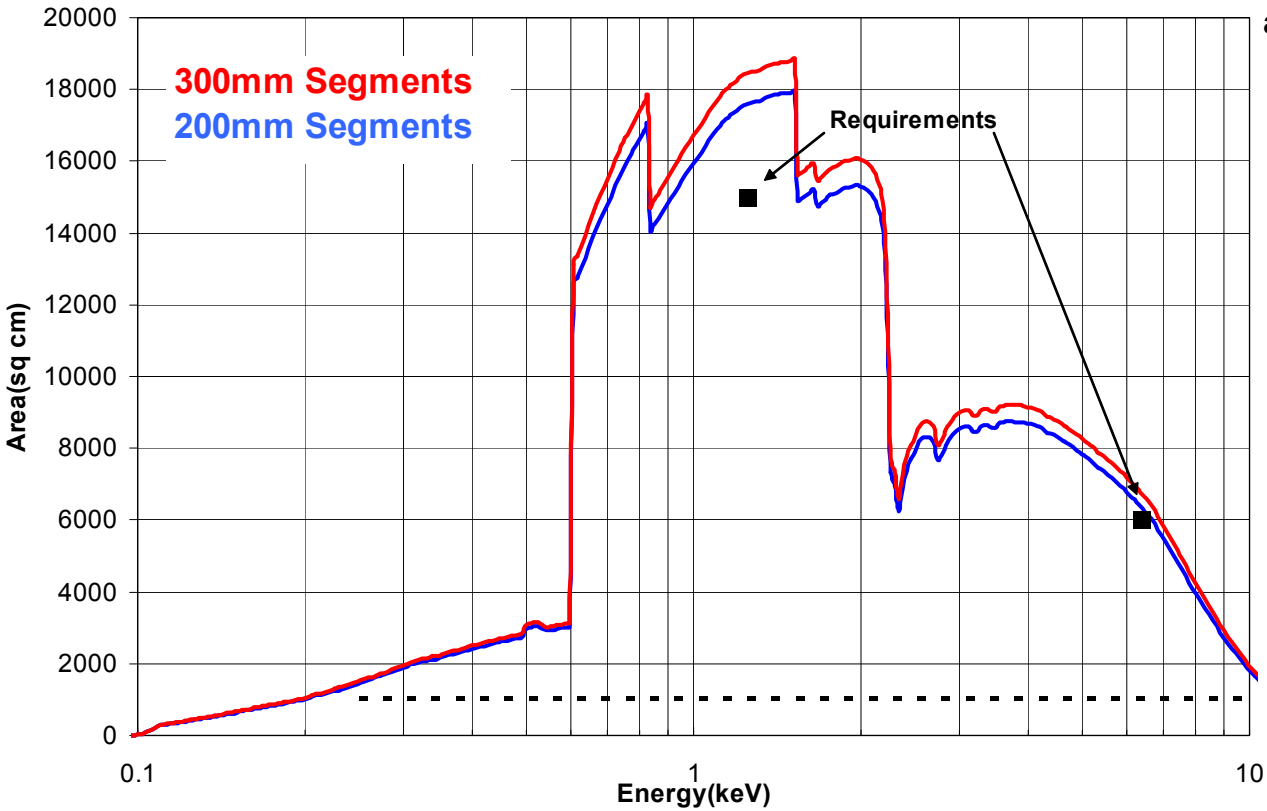
Inner Modules (6 P and 6 H)

- *Modular Housing Design*
- *Segment length range:*
  - *200mm (230 shells)*
  - *300mm (167 shells)*
- *Blockage of radial and azimuthal structure accounted for in detail, with individual shell blockage factors*
- *Gold coating, 16.965 gms/cm2*
- *Inner/Outer split at R ~= 445mm*
  - *Gratings mount over outer modules*
- *Azimuthal structure eliminates ~4 mirrors*
  - *For example, in 230 shell design, shells 89, 90, 91 and 92 are removed*

Grating/CCD Impacts on Effective Area

- *Two grating options now under consideration:*
  - *In-plane*
  - *Off-plane*
  - *Detailed work on area and spectral resolution for both options now underway in support selection process*
  - *Work this summer indicated that in-plane grating efficiencies used in the area prediction were un-realistically high. These have now been revised to more realistic values and are included in current area prediction.*
- *Event Driven CCD (EDCCD) is now baseline*
  - *EDCCD uses a surface deposited 200A° Aluminum optical blocking filter (OBF) which increases effective area of grating/CCD instrument*
  - *This OBF is included in area prediction*

SXT Effective Area Prediction



Mission Effective Area Requirements and Area Predictions for Candidate SXT Configuration

-Segmented Optic
-200mm Segment Length
-230 Shells
-Au Coating
-4 S/C
-GSFC Modular Design
-Structural Blockage varies with E
-Radial and Circumferential rib blockage included
-Gratings over outer 90 shells

-In-plane Grating (Typ)
-Revised Grating Efficiencies (lower)
-EDCCD - 200 A° Filter

-Baseline Calorimeter

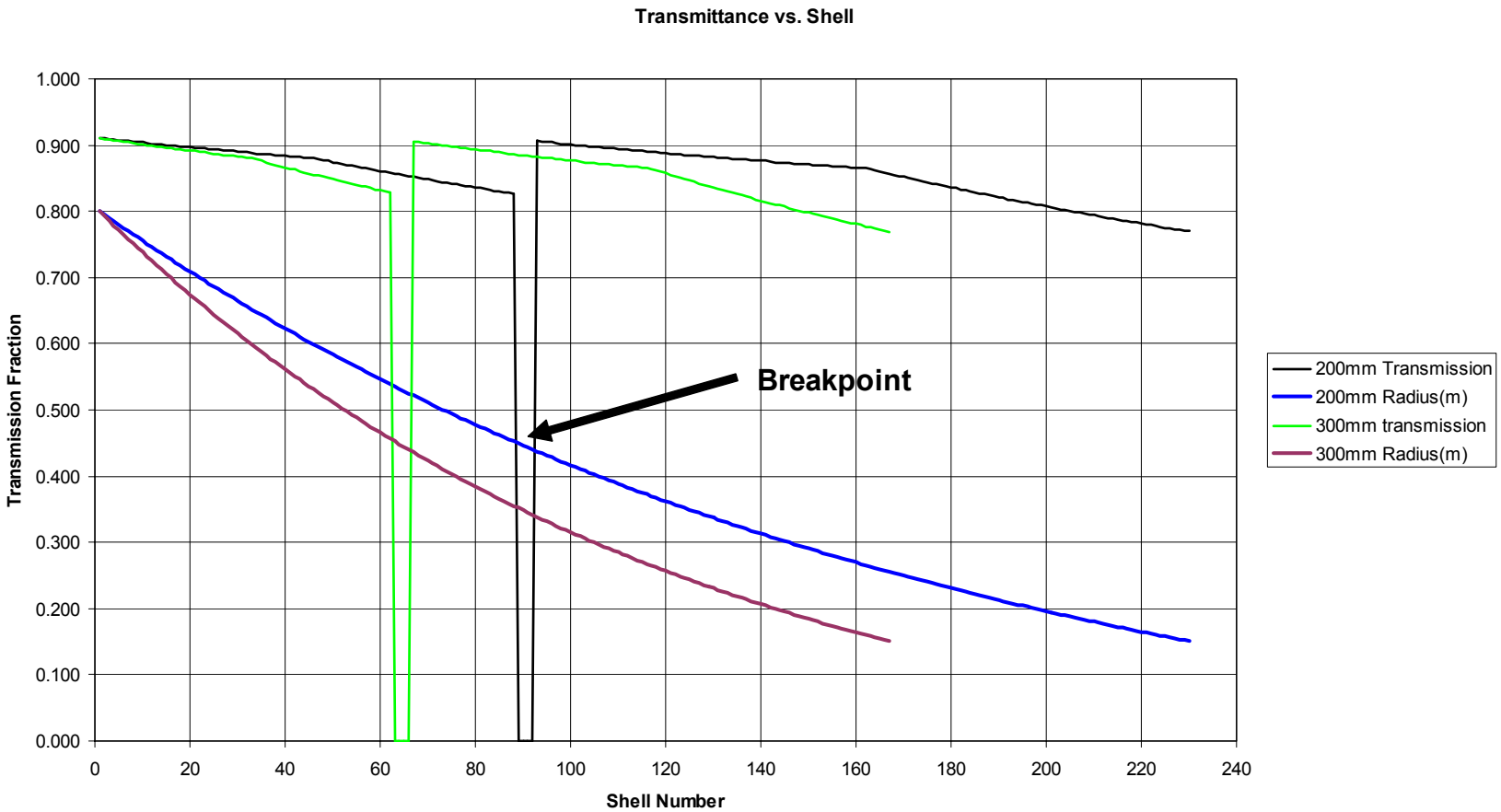
Area where
R > 300,
(thru typical Instruments)

15 Arcsec (HPD) Image Requirement – No changes

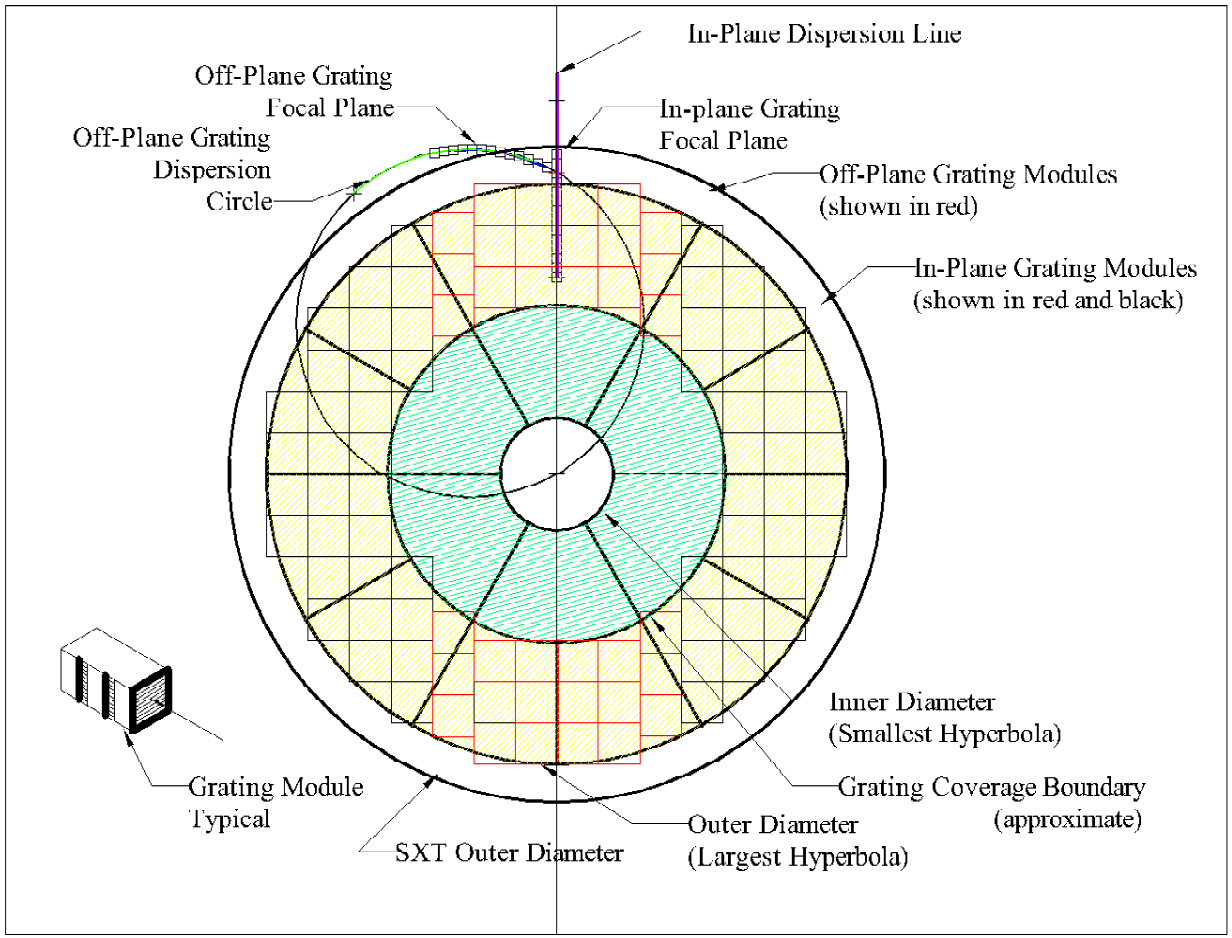
SXT/Calorimeter Image Error Budget - Requirements							
ITEM (HPD - arcsec)	RQMT	Margin	Budget Allocation				
On-orbit Image Resolution	15.00	6.80	13.37				
Detector pixelization error (5 arcsec pixels)				4.08			
On-Orbit Telescope				12.73			
Telescope level effects					5.29		
Image Reconstruction errors (over obs)						4.24	
Attitude knowledge drift							3.00
SXT/SI focal plane drift							3.00
SXT/Telescope mounting strain						2.00	
SXT/SI vibration effects						2.00	
SXT/SI misalignment (off-axis error)						1.00	
SXT/SI Focus Error						1.00	
SXT Optics - On-orbit performance					11.58		
SXT Mirror launch shifts						2.00	
SXT thermally induced errors (ΔT driven)						3.61	
Housing/glass CTE mismatch							3.00
Epoxy/glass bi-layer effects							2.00
Long term material stability effects						1.00	
SXT Mirror, As-built						10.77	
Assembly (bonding) strain							3.00
Alignment Errors (Using CDA)							3.00
Optical Elements							9.90

Backup Slides

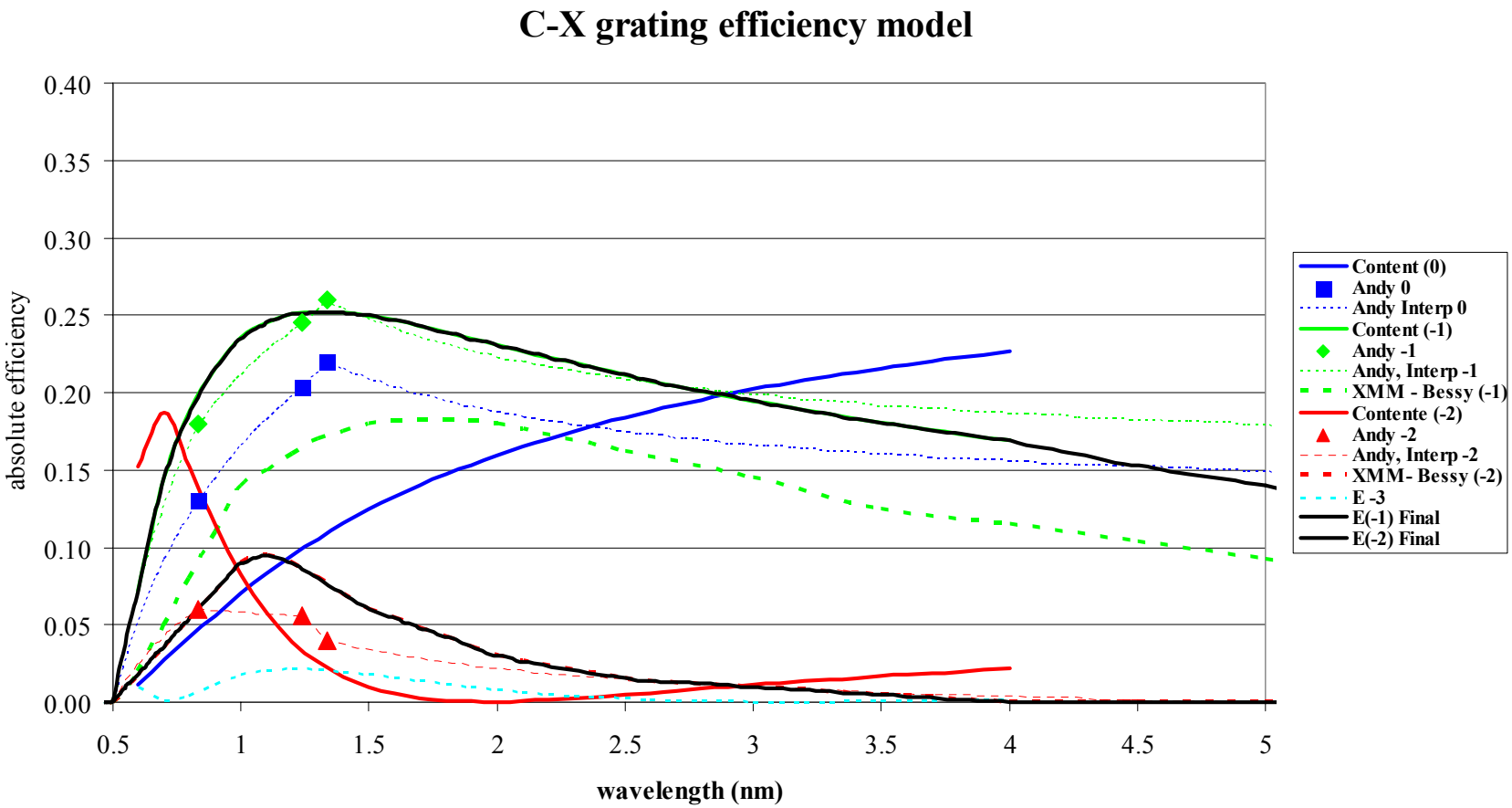
SXT Structural Blockage



Grating/CCD Impacts on Effective Area



In-Plane Grating Efficiency Plot



Notes on In-Plane Grating Efficiencies

- *In-plane grating efficiency curves used in area calculations over past several years were un-realistically high.*
  - *Both grating teams (Columbia/Colorado) agreed on this point*
- *There is a program office need for an updated set of values for the in-plane design (need to know where we stand on area vs. requirement)*
- *Off-plane efficiencies will be determined by experiment over next year*
- *Three sources of grating efficiency information were examined:*
  - *Experimental data from MIT gratings from A. Rasmussen (3 wavelengths/orders 0, 1 and 2)*
  - *Published data on XMM grating efficiencies (RGS-COL-CAL-99005)*
  - *Analytical calculations by Dave Content of GSFC (tried to fit experimental points)*
- *Data are inconsistent:*
  - *MIT grating data for -1 order is above XMM data (0.25 vs. 0.18)*
  - *XMM data higher than experimental for order -2*
  - *Second order peak efficiency may well have been missed due to limited number of wavelengths measured on MIT gratings*
- *Decided that best approach would be to use Dave Content's calculation for first order since it was tuned to match measured data*
- *Use XMM data for second order since it has the right shape (it may be too high)*

Reference Mission Architecture and Design Update

Dr. Govind R. Gadwal
Mission Systems
Goddard Space Flight Center

Reference Mission Architecture and Design

- *Continuing development of reference configuration for demonstration of feasibility, establishment of technology requirements and development of cost estimates*
- *Four satellites in mission; launched two at a time on Atlas V or Delta IV*
  - *Atlas V has successfully completed its maiden launch in August*
  - *Delta IV maiden launch is scheduled in October*
- *Each satellite configuration comprises*
  - *One Spectroscopy X-ray Telescope (SXT) with 1.6 meter diameter segmented optics*
  - *Three Hard X-ray Telescopes (HXTs) with 0.4 meter diameter optics*
  - *One fixed optical bench to provide 10 meter focal length to optics*
  - *One Calorimeter Detector Assembly and one CCD Detector Assembly for SXT; and one CdZnTe Detector Assembly for each HXT*
  - *Separable spacecraft bus and instrument module*

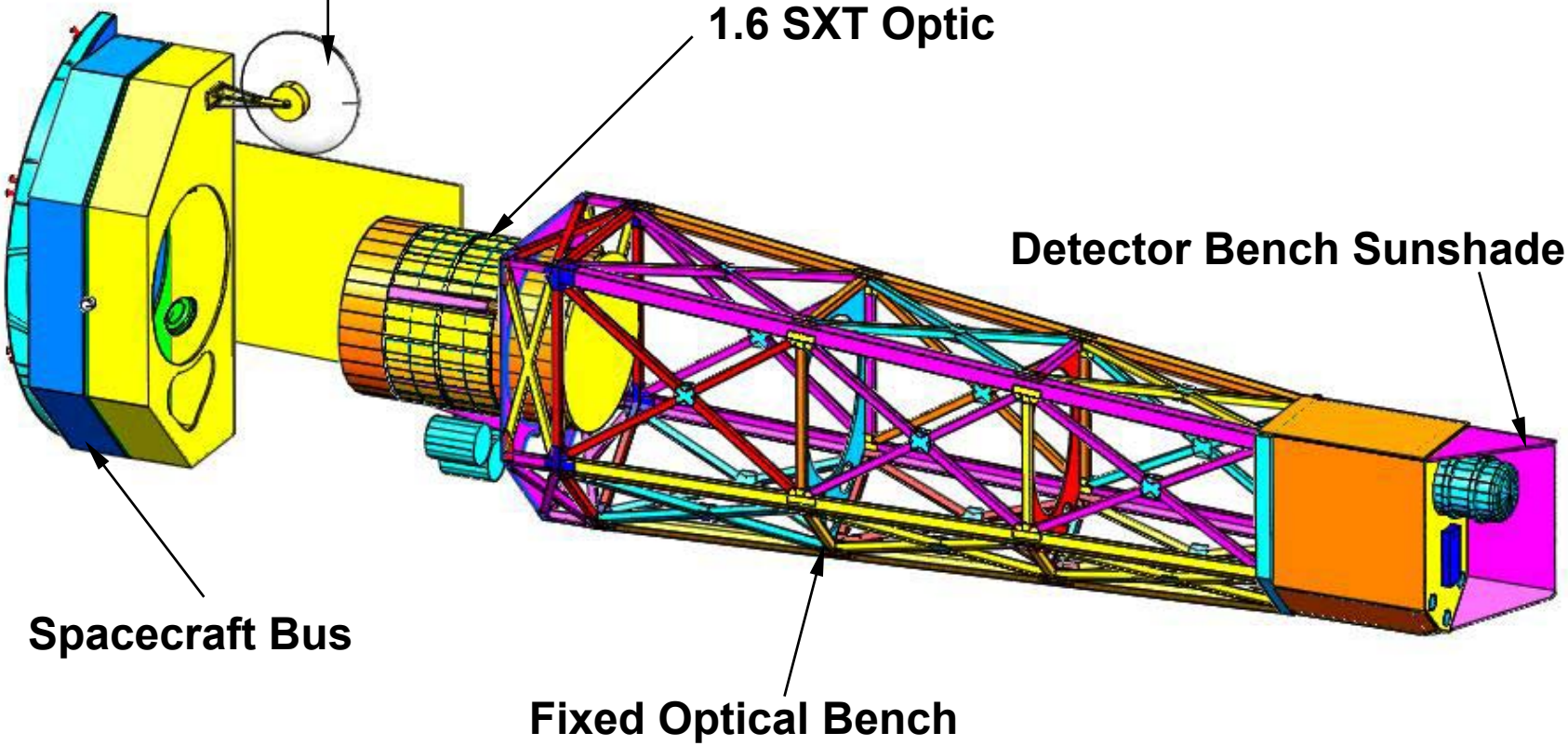
Reference Mission Architecture and Design Updates

- ***Incorporated Fixed Optical Bench***
  - ***Increases reliability***
  - ***Reduces mass***
- ***Included Segmented SXT Optics***
- ***Updated configurations to include impacts due to new top-level requirements***
  - ***Imposed new timing requirements***
    - ***Needed 100 microseconds timing accuracy for science***
  - ***Imposed new bright source requirements***
    - ***Increased mission requirements to 40000 counts per second maximum***
    - ***Imposed new pixel requirements to 1000 counts per second maximum***
- ***Update advances in instruments, structures, and subsystems***

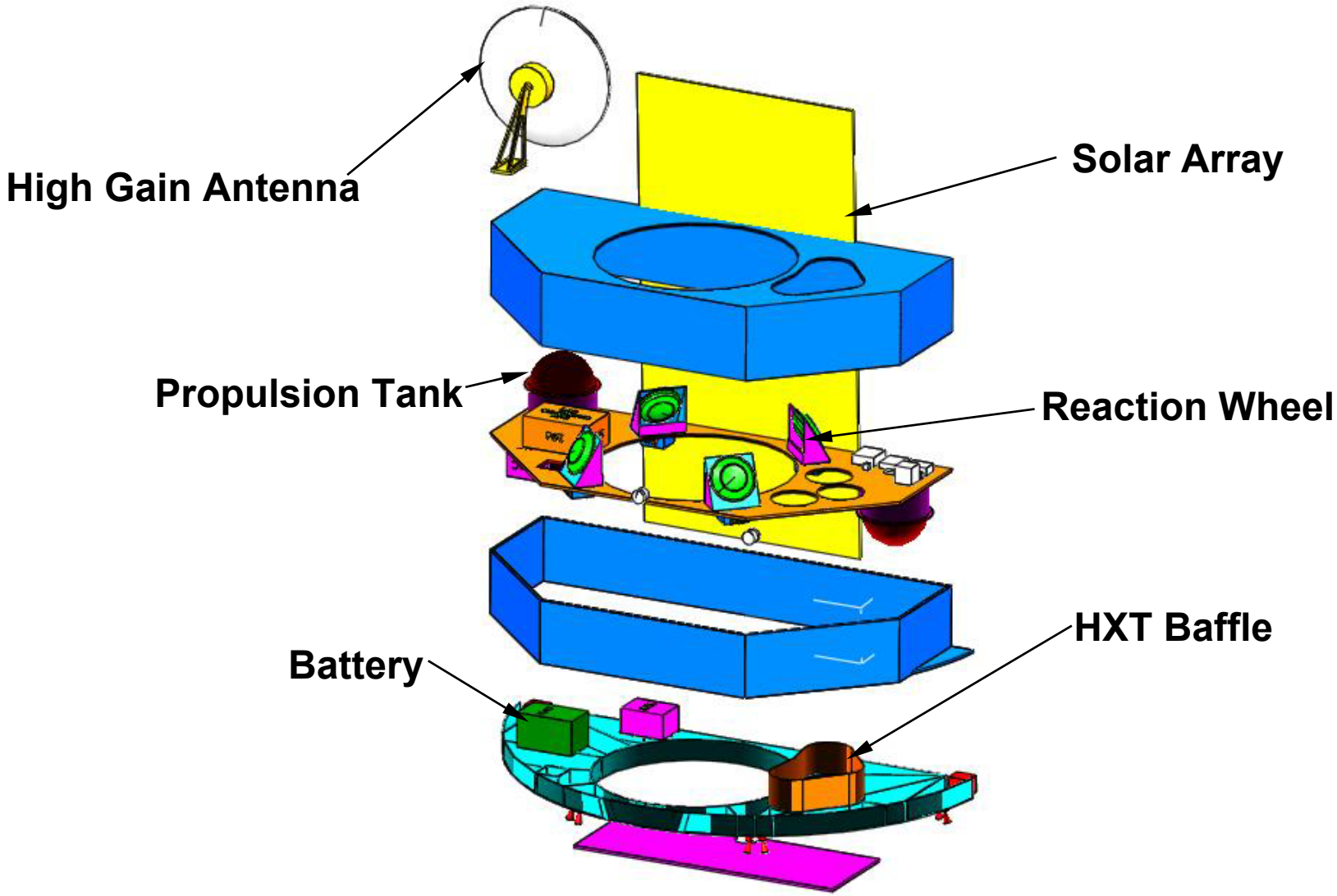
Reference Mission Architecture and Design Updates (cont.)

- *Investigating two potential launch vehicle separation systems*
- *Completed preliminary study by GSFC/SAO to verify pointing requirements are achievable*
  - *Mechanical analysis*
  - *Thermal analysis*
  - *Attitude control analysis*

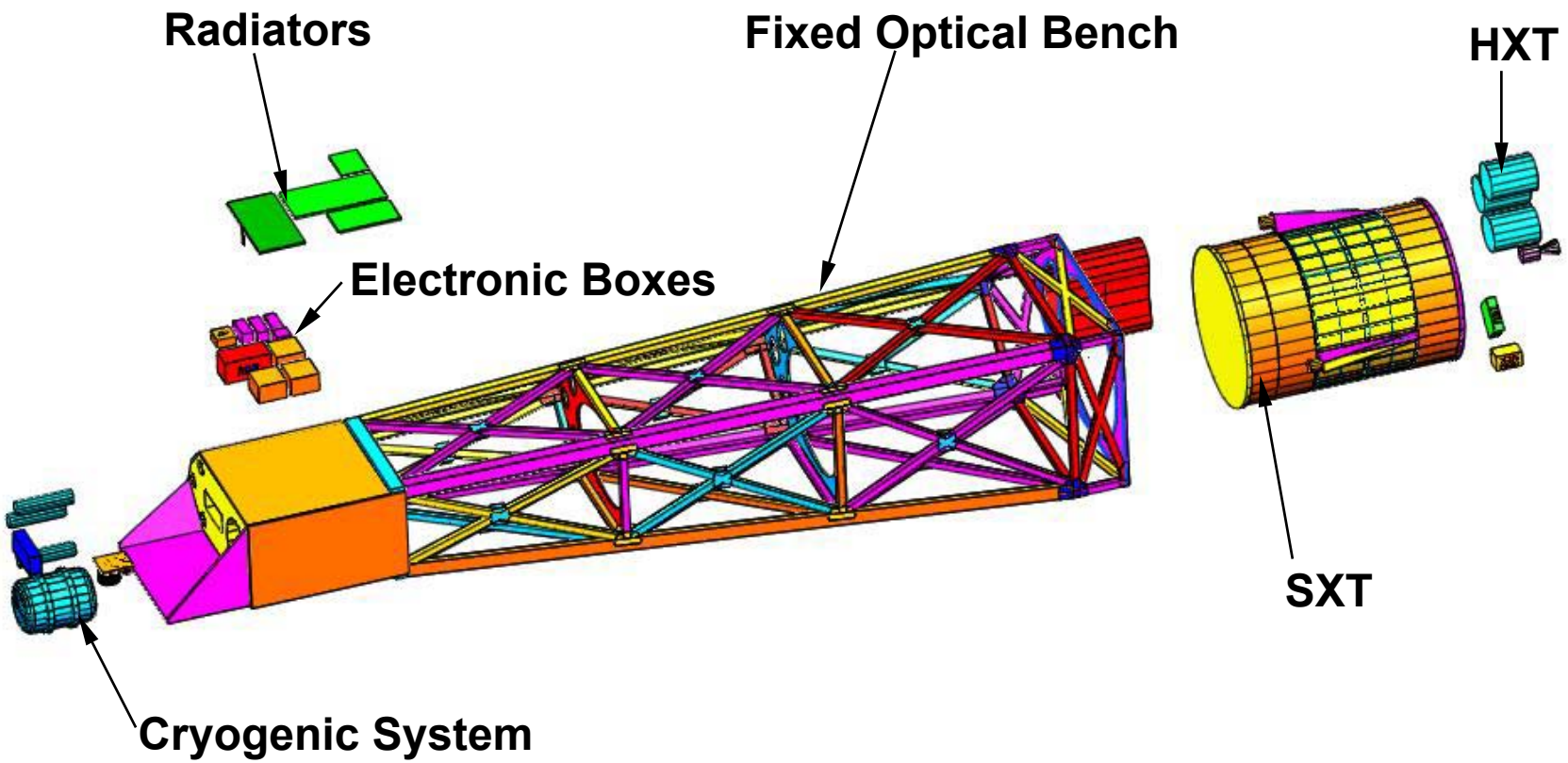
Fixed Bench Configuration



Spacecraft Module



Instrument Module



Cryocooler Technology Status

- *Advanced Cryocooler Technology Development Project is constituted to develop cooler for Constellation-X, JWST, TPF*
- *Four Teams are under study contract*
  - *Ball Aerospace; Boulder, Colorado*
  - *Creare Inc.; Hanover, New Hampshire*
  - *Lockheed Martin; Palo Alto, California*
  - *TRW; Redondo Beach, California*
- *Kickoff meetings were held in April 2002 and midterm reviews were held in June 2002*
- *Preliminary Design Reviews were held in early September, with final reports due on September 30*
- *Demonstration contracts will be awarded in October so that engineering model cooler will be delivered in end CY 2004*